51-92.R 26

THE ROYDEN MARBLE MACHINERY C

ABRASIVE MACHINERY

51/92

Compliments of
Arthur C. Fraser & Urma

Royden Marble Machinery Co.

INCORPORATED

PATENT OFFICE
JUN 3 1907
DIVISION XXVII

Designers of and Contractors for Abrasive Machinery
for Use in the Marble, Slate and Soft Stone Trades

OFFICES

METROPOLITAN LIFE BUILDING, 1 MADISON AVE., NEW YORK CITY

Received in Div. 27 U.S. Patent Office June 3d 1907

SHOP EQUIPPED WITH CARBORUNDUM MACHINERY

PREFACE

The remarkable artificial abrasive carborundum was discovered by Acheson. Since its discovery, its use in various fields has been steadily growing. Sporadic attempts have been made to utilize it in the stone industry.

It was not, however, until Offenbacher of Germany, Blanpain and Jaspart of France and Anderson of Scotland began to experiment with it that its great cutting power in marble was recognized.

These foreign experimenters though they attained a limited success in cutting small moulds, failed to develop the possibilities of carborundum and never made a commercial success of it in the marble industry.

The designer of the machines shown in this catalogue started experimenting with carborundum on marble early in 1904. The first step taken was to abandon the foreign idea of having one machine (miscalled universal) to perform various classes of work. The next step was a thorough investigation of the laws of abrasives, resulting in the correction of many erroneous opinions and the discovery of many hitherto unexpected properties.

After a year's study of the conditions necessary to make this process successful, building of the machines was begun. The following have been selected as the fundamental types:

Drum Rubber, Turning-head coper, Gang coper, Cut-off coper, Two-wheeled moulder, Counter-sinker, Continuous Feed Base Polisher, Polishing Rings and Lathe.

They are of the simplest possible design, combining strength and durability. They are easy to operate, accessible, have interchangeable parts and are built according to the latest and most approved American ideas.

The handling of the water in these machines has received careful attention. All the jets are properly designed and standardized. The hoods fully protect the operator and machine from the water thrown from the wheels. All tables are surrounded by gutters carrying the water and entrained grit away. The wheels and operating mechanism are in all possible cases placed above the level of the table as an additional precaution. Furthermore, the tables are operated by a continuous nut feed. As a result of these features there are no moving parts below the level of the table exposed to the rust and wear of the water and grit.

The most important feature of the machines is the correct design and mounting of the spindles for rotating the wheels. The great amount of power applied and the high speed at which they are run make the duty on

this part of the mechanism greater than that on any other class of high speed machinery. Consequently, special attention has been given to the correct selection of bearings and the arrangement of the belting. As a result, the spindles rotate with a minimum of friction and the wear on the bearings is slight.

We have spindles which have been running eight hours a day at 2,000 revolutions per minute for over two years and the bearings are still in excellent condition. The latter are fully protected from water and grit and in no case have they been injured from this cause.

While different types of bearings (foreign and domestic) are used, chosen carefully for their respective duties, they are all standard sizes and can be replaced in a few moments.

The counter shafts and feed mechanism are mounted on solid and substantial frames with ball bearings throughout. The mechanism for varying the speed is a well known and reliable type.

The belting, owing to the high speed of the spindles has been the subject of much thought. It has been reduced to the simplest possible arrangement. The rapid deterioration of high speed belting is well known Straight lines, correct crowns, and ample distances between centers have been used, making this wear very small.

Either individual motor or shaft drive may be used.

The machines are fully protected by patents.

The first idea was to develop attachments to existing machines, but after a year's trial they were abandoned as impractical. No existing machines will stand the severe demands of this process.

THE CARBORUNDUM PROCESS

Before describing these machines individually it is desirable to give a brief description of the carborundum process which differs in many ways from the present method of working marble.

As soon as the slabs come from the gang saws they are run through the Drum Rubber in their entire size. The rubbed slabs are then stored in the yard. Here they are selected, matched and their respective sizes marked by an operative called a marker.

It may be seen from this what great advantages accrue from storing them in the finished state. It greatly facilitates accurate selection and matching. Not only is the veining and color of the marble fully exposed, but as the sizes only are marked, one marker can take care of an entire yard; an obvious advantage over the present method where often many copers are engaged selecting marble for one job.

The marked slabs are now taken from their places in the bins by special grappling hooks and placed on one of the copers. (All the machines must be under travellers.) If it is strip or tile work, it goes to the Gang Coper, after which the strips are cut into their proper lengths on the Cut-off Coper. If, however, panels or large rectangular pieces are to be cut, the slab is placed on the Turning-head Coper.

In all cases, pieces are cut to exact sizes leaving perfect arrises requiring no subsequent rubbing on the beds. Beside leaving a finish equal if not superior to that left by the latter, it does away with a great deal of handling which is always a considerable expense connected with the rubbing beds.

The pieces are next taken to the polishing machines. These are equipped with special polishing rings, representing the most careful and elaborate investigation of the properties of abrasives on marble. Base and strips are polished by the automatic Base Feed Polishing Machine.

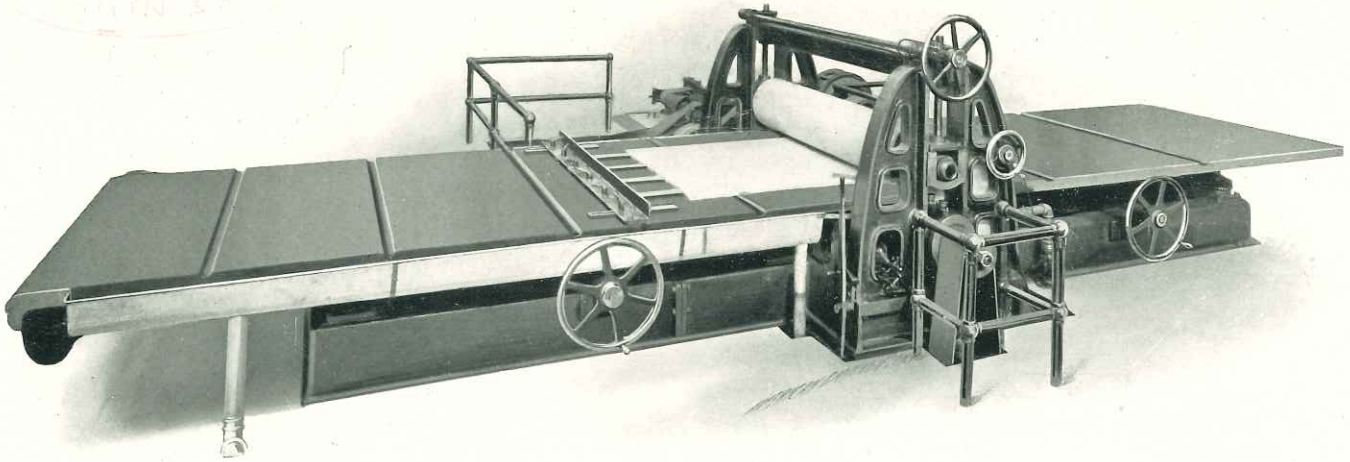
These rings are the most efficient gritting heads known, and while especially adapted for the surface left by the Drum Rubber are equally successful on the surface left by the rubbing bed.

The Two-wheeled Moulder, Countersinking Machine, Lathe and Mosaic Machine, as their names indicate, take care of a familiar class of work requiring no description.

Though the machines will do a large variety of work they are primarily intended for interior marble.

While we are giving the capacities of these machines in marble only, they are equally efficient in onyx, slate and the soft stones.

They are described in the following pages in their natural order.



DRUM RUBBER

PATENT OFFICE
JUN 3 1907
DIVISION XXVII.

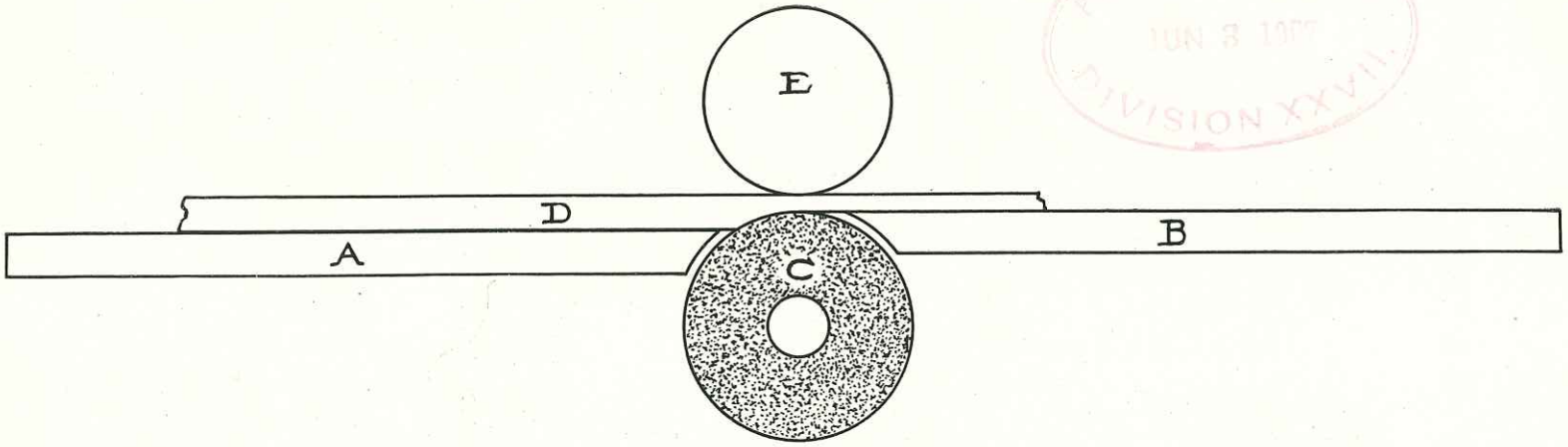


DIAGRAM OF DRUM RUBBER

DRUM RUBBER

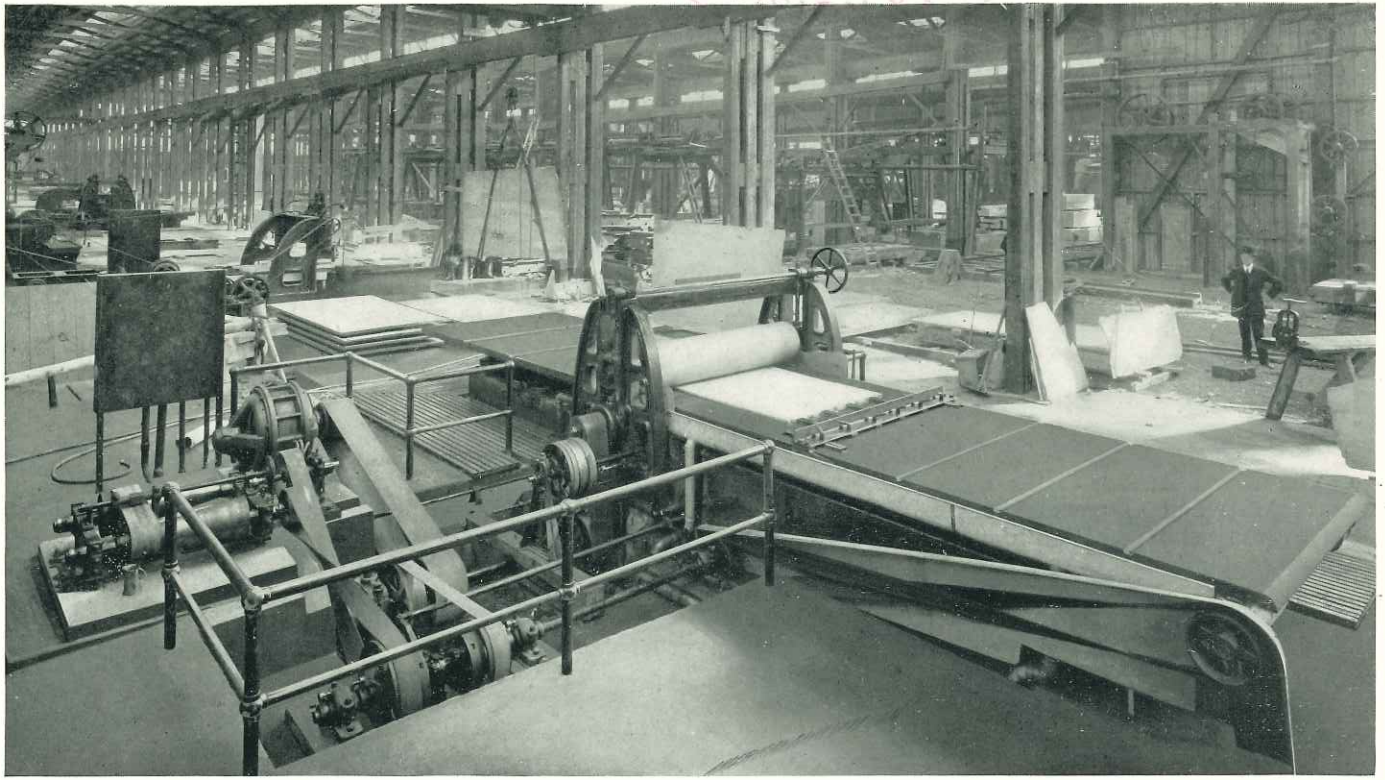
The Drum Rubber is the most important marble machine designed in recent times. It does the work done by the rubbing beds now in use—work which is the largest single item of shop expense.

In designing this machine two types were considered, the first having the drum over the marble and the second having it under.

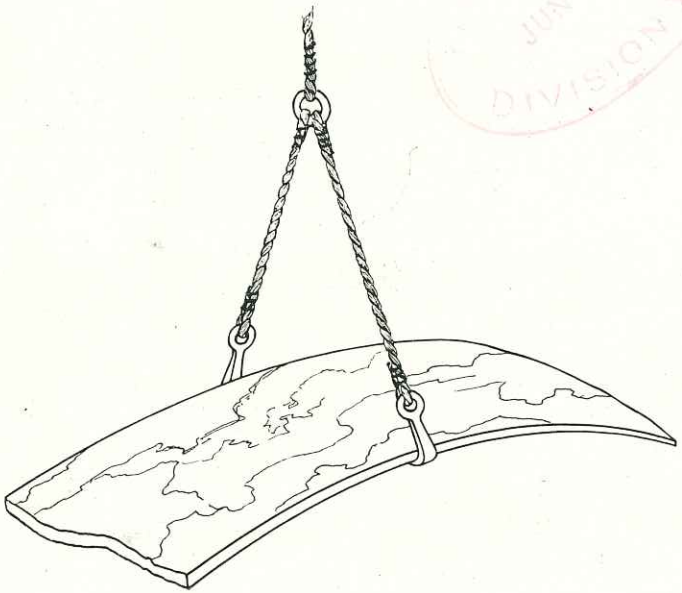
The former was studied very closely, and experiments were made, but it was finally given up as being impractical. Not only is it impossible to prevent the slabs from being fractured, but the operative conveniences of the under type are so far superior, that the overhead type was abandoned.

For the last twenty years, attempts have been made to construct a successful overhead type in the glass industry. Notwithstanding the fact that rubber was placed under the glass, the drum suspended on swinging frames, etc., it never became a commercial success, although glass is more flexible than marble and has greater homogeneity.

PATENT OFFICE
JUN 3 1907



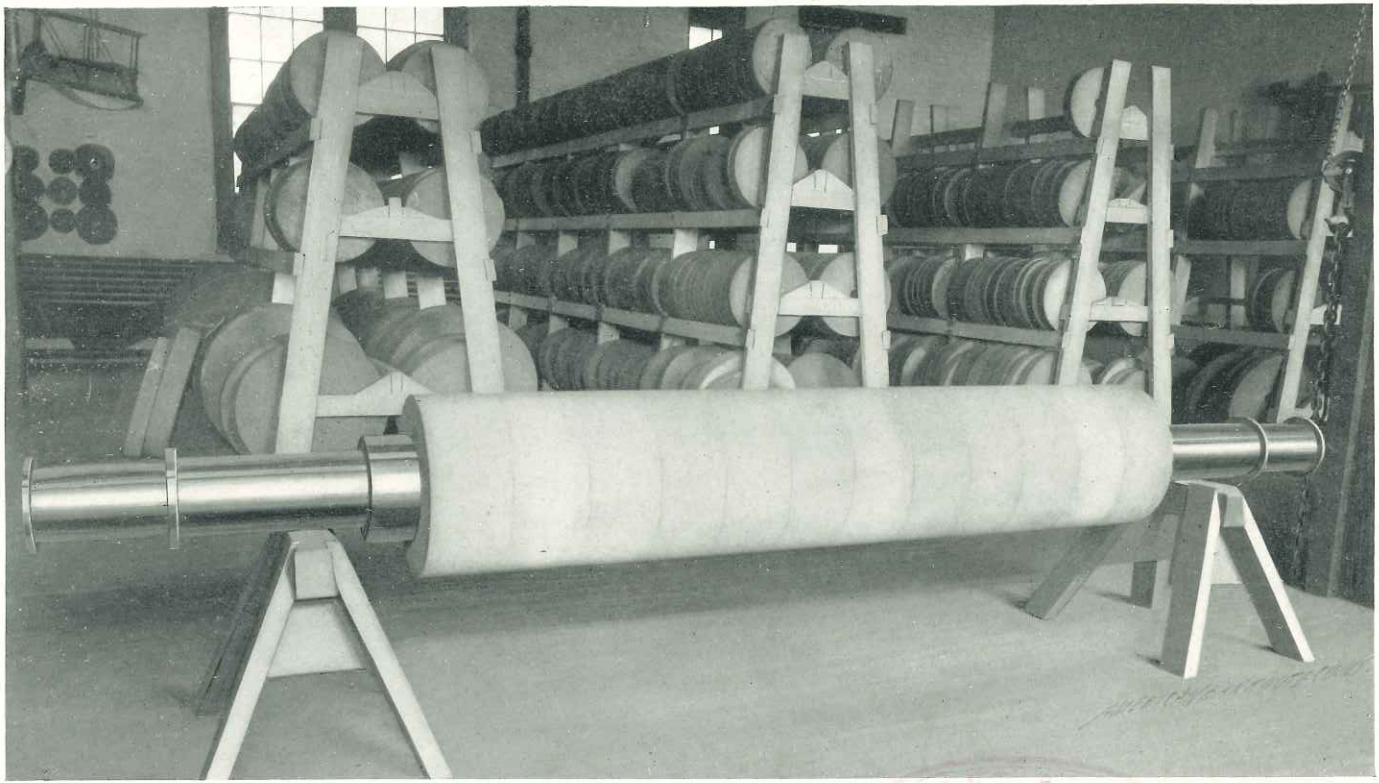
DRUM RUBBER SHOWING TRANSMISSION



Cut showing (exaggerated) the flexibility of marble
Advantage is made of this characteristic in the design of the Drum Rubber

The machine consists of two tables, A and B, between which is situated the carborundum drum C. The marble slab D is placed on the table A and pushed over the drum by moving dogs on to the table B. The surface of table B is kept flush with the top of the drum. The other table, however, is lowered below the top of the drum, the thickness of the cut to be taken. As the marble is pushed over the drum, it is pressed down by the idler E, an iron cylinder, covered with a thick coating of rubber.

Three pre-eminent advantages are gained from this arrangement. First, the cut throughout the entire surface of the slab being uniform, no unnecessary marble is removed, notwithstanding the slab may be of varying thickness. Consequently, the machine is always working at its maximum efficiency. Second, the danger of fracture is completely eliminated. The most delicate and fragile marbles, even slabs with open seams running ¾ of their width have been run through this machine successfully. Third, the machine does not require adjusting for each slab as is necessary in the overhead type. Once adjusted for a given cut (an operation requiring but a moment) slabs of all sizes, thicknesses and kinds can follow each other consecutively. The slab is rubbed passing over the drum once, except in cases of very badly sawed slabs.



CARBORUNDUM DRUM

PATENT OFFICE
JUN 3 1927
DIVISION XXVII

The drum is the largest abrading cylinder in existence. It consists of a massive steel shaft upon which is slipped a carborundum sleeve. This sleeve is made up of sections which are bevelled, thus avoiding the possibility of leaving a rib on the marble, where the sections join.

The proportions of this drum have been the subject of careful calculation. The deflection due to weight and centrifugal force has been reduced to a negligible quantity. The danger of erratic vibration due to critical velocities has been avoided by determining the correct speed. So successful has this been, that when the drum was tested at Niagara Falls, its vibration at 1,000 revolutions per minute was found to be less than 1-100 of an inch. The construction of such a massive abrasive cylinder running at such high speed has never been accomplished before.

While the drum does not wear down, it slowly becomes glazed, so that it is necessary daily to cut it off by means of a diamond.

This is set in an automatic tool attached to the machine. The operation of dressing the drum requires but a few moments and removes only a minute fraction of an inch from the surface.

It is a simple operation to replace the worn out sleeve with a new one.

To facilitate rapid handling of slabs (an important factor) channels are cast in the tables to enable the grappling hooks to be easily attached to same. As stated in the preface, it is necessary that the machine should be served by a crane.

Capacity: Will rub 3 to 6 sq. ft. per minute, or 800 to 1,200 sq. ft. per day of 8 hours, depending upon the kind of marble, size of slab and quality of sawing. Thickness of slabs 1 ft. or less.

For machine, floor space required: 30 ft. x 18 ft.
For transmission floor space required: 12 ft. x 12 ft.

Maximum height: 7 ft.

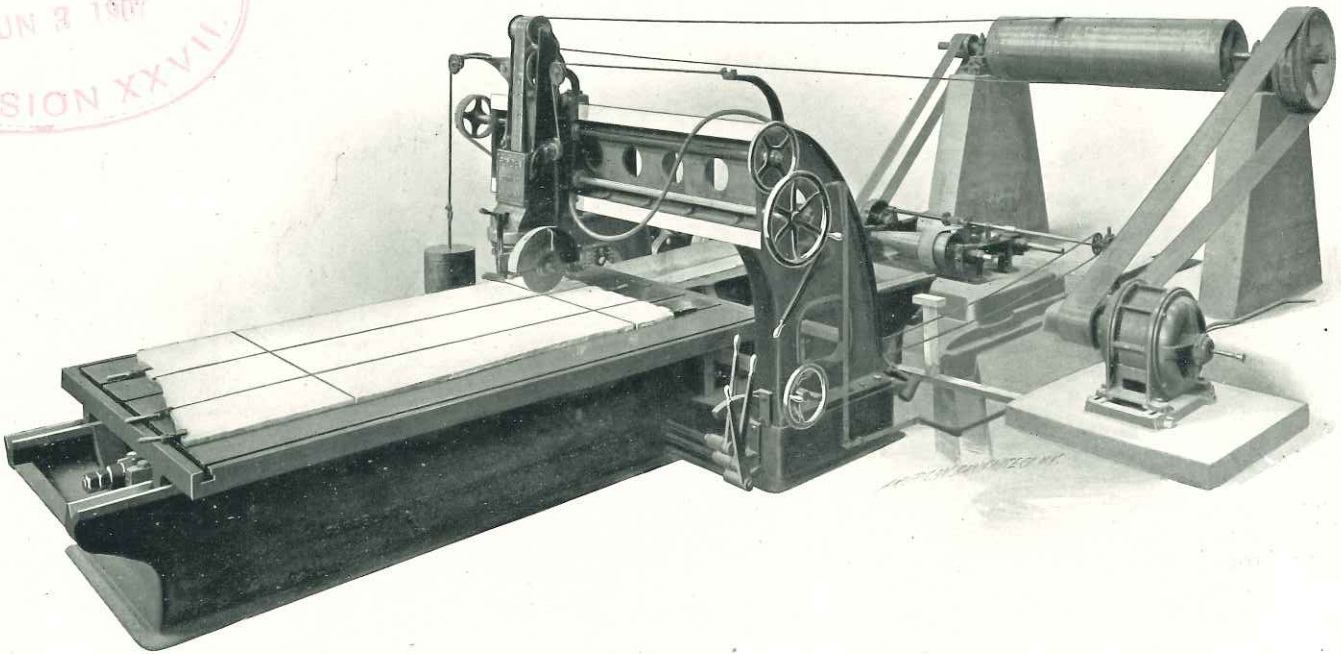
Horse power required: 65.

Water required: 100 gal. per minute.

Weight: 20 tons.

Size of slabs accommodated: 6½ ft. x 12 ft.

PATENT OFFICE
JUN 3 1907
DIVISION XXVII.



TURNING-HEAD COPER

TURNING-HEAD COPER

The principal feature of this machine is the turning head, which makes it possible to cope in two directions without shifting the marble.

The slab is placed upon a table and held in position by low, quickly operated clamps (seen in photograph). For longitudinal cuts the head is swivelled, placing the wheel parallel to the length of the table. The head is lowered until the wheel is within a thirty-second of an inch of the surface of the latter. As the table moves, the marble comes into engagement with the wheel, and is cut into exact sizes.

For transverse cuts, the head is lifted, and the wheel turned at right angles to its former position. In both positions it is caught and held in place by an automatic lock. The wheel is lowered as before, but in this case the head moves and the table remains stationary.

The head is readily swivelled by hand and the feed changed from head to table, or vice versa, by shifting a single lever.

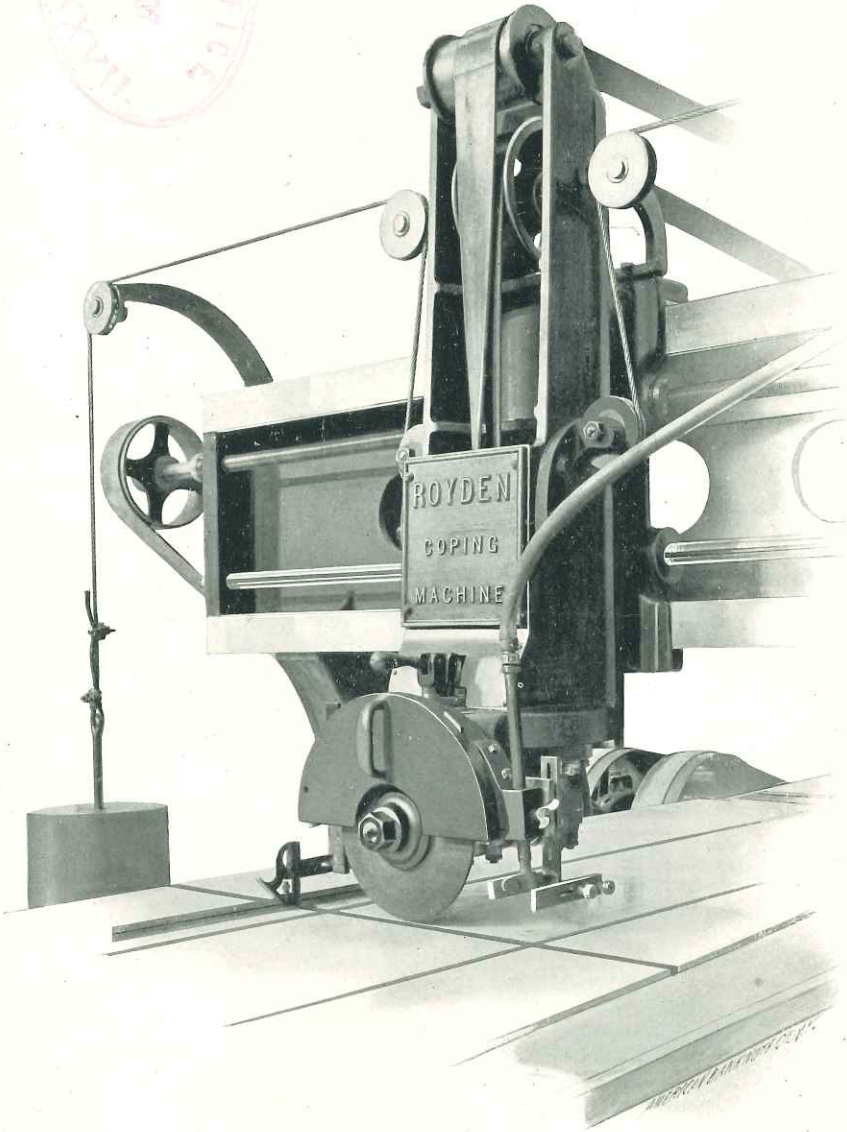
The wheels are 10, 12 and 14 inches in diameter and are 5-16 of an inch thick. After two years experimenting with all shapes and thicknesses of wheels, we have settled upon 5-16 of an inch as the most practical, and have adopted this as standard.

Owing to careful construction of the machine, the breakage of wheels is reduced to an inconsiderable item. These last from three to six days before wearing down too far for further use.

The water jets are carefully designed.

The marble is placed upon the table, saw-face down. The face and top arris of the cut is left by the wheel in perfect condition. The lower edge, however, has a slight burr, as the wheel does not cut quite through the marble. This burr being only 1-32 of an inch thick can be removed by one sweep of the file, and is therefore of no consequence.

In cases where it is necessary to preserve the top and bottom arrises, a little plaster is spread on the



DETAIL OF TURNING-HEAD COPER

Showing wheel taking transverse cut

bottom of the slab. The wheel then copes entirely through the marble leaving both edges faultless.

Slabs having a thickness of 2 inches or less are coped by one passage of the wheel. Slabs four inches, which are the thickest the machine will take, require several cuts.

Two brass measuring gauges, one on each side of the wheel, enable the operator to adjust the head without stopping the wheel or bringing it into contact with the marble. This measuring device is a very important feature. By means of it, the slabs are cut to exact sizes quickly and accurately.

Much of the success of this machine is due to the ease and quickness with which the wheels can be adjusted to the work.

For machine, floor space required: 20 ft. x 8 ft.

For transmission, floor space required: 14 ft. x 14 ft.

Maximum height: 8 ft.

Size of table: 6½ ft. x 12 ft.

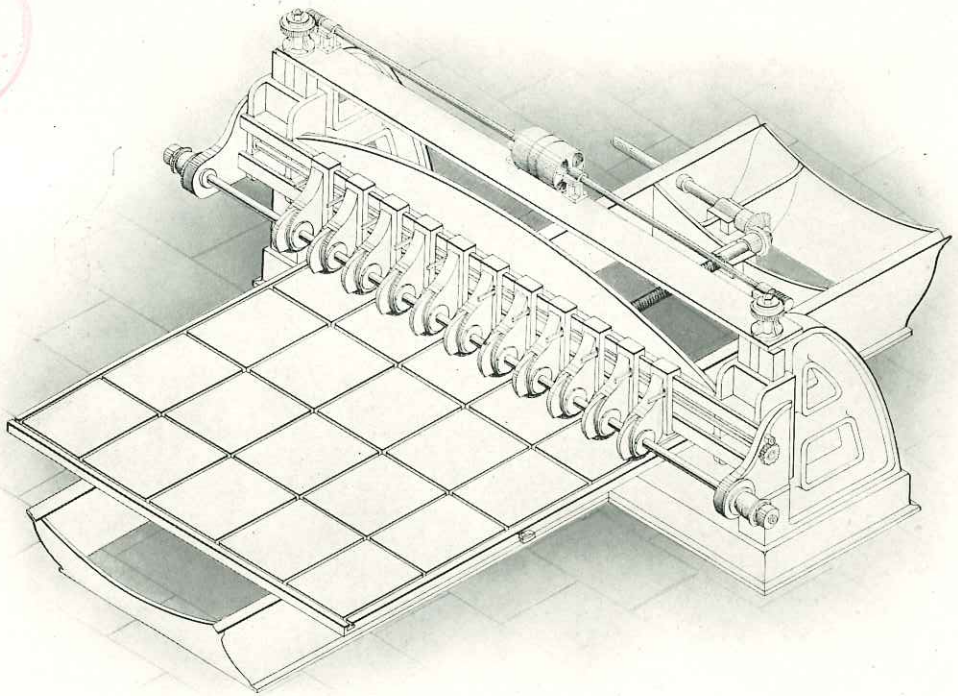
Speed variation of feed (table and head): 6 inches to 3 ft. per minute.

This machine copes ⅞ inch Italian at the rate of 3 ft. per minute.

Weight: 9 tons.

Horse power required: 15.

PATENT OFFICE
JUN 3 1987
DIVISION XXVII



GANG COPER

GANG COPER

This machine is designed for strip and tile work.

Thirteen wheels are run parallel to each other and are operated by a single shaft. Each wheel has a separate bearing and head. The distance between these heads may be kept equal or not as desired. In the former case the distance is varied automatically by a single mechanism. In the latter case, however, the distance adjuster is thrown out of gear and each head is placed independently.

The minimum distance between the wheels is 6 inches, which is the smallest base generally required. If however, narrower strips are desired, an extra cut is taken, all the wheels being moved over simultaneously by turning a hand wheel.

When less than thirteen cuts are required, the idle heads are pushed aside, the slide being long enough to accommodate them.

This machine can be built with a turning table so that tile can be cut without shifting the marble. The quality of work is the same as that done by the Turning-head Coper. It is designed to take thirteen cuts in 7/8 inch Italian, at the rate of 6 inches per minute.

To dress the wheels, it is necessary to keep them of even size. To do this, the slide holding the heads is adjusted so that the wheels are about 3/4 of an inch above the table. A dresser is then pushed under each one.

As a money saver, this machine is second only in importance to the Drum Rubber.

Size of table: 6½ ft. x 12 ft.

For machine, floor space required: 20 ft. x 12 ft.

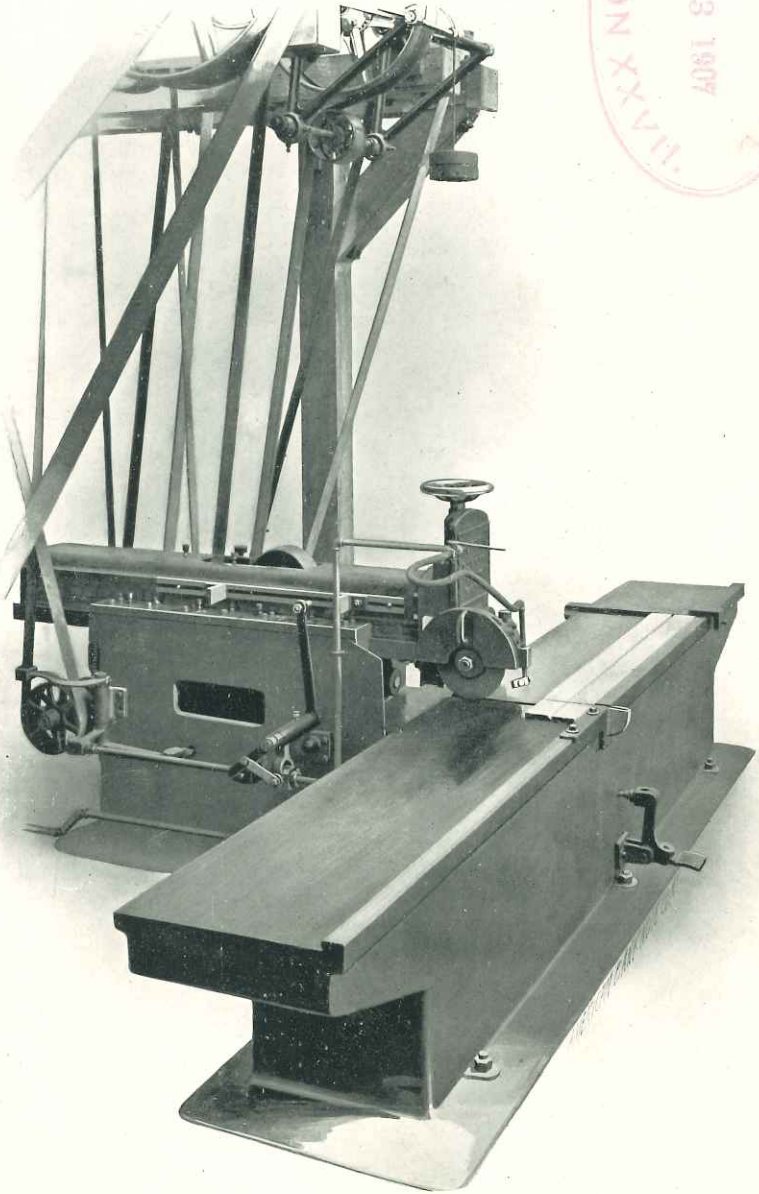
For transmission; floor space required, 15 ft. x 10 ft.

Maximum height: 8 ft.

~~51-34.6~~ 26
451-150

catalog Roydon Marble mach. Co
51/92

DIVISION XXX PATENT OFFICE JUN 3 1907



CUT-OFF COPER

CUT-OFF COPER

An auxiliary to the Gang Coper, and a very useful addition to the Turning-head Coper, is the Cut-off machine.

It is built to cut strips or moulds into desired lengths, and to cut tile and similar small work.

The marble strip or mould is placed on the bed. A slide carrying the Coping wheel moves at right angles to the latter. The operator presses a foot lever, which starts the slide travelling forward, bringing the wheel in engagement with the marble. When the wheel has completed the cut, a trip automatically throws in the reversing feed, and the slide returns to its former position.

For convenience in cutting tile or pieces of uniform length, a gauge is placed across the bed, which does away with the necessity of measuring each piece.

This little coper does an immense amount of work and is an invaluable machine in any marble shop.

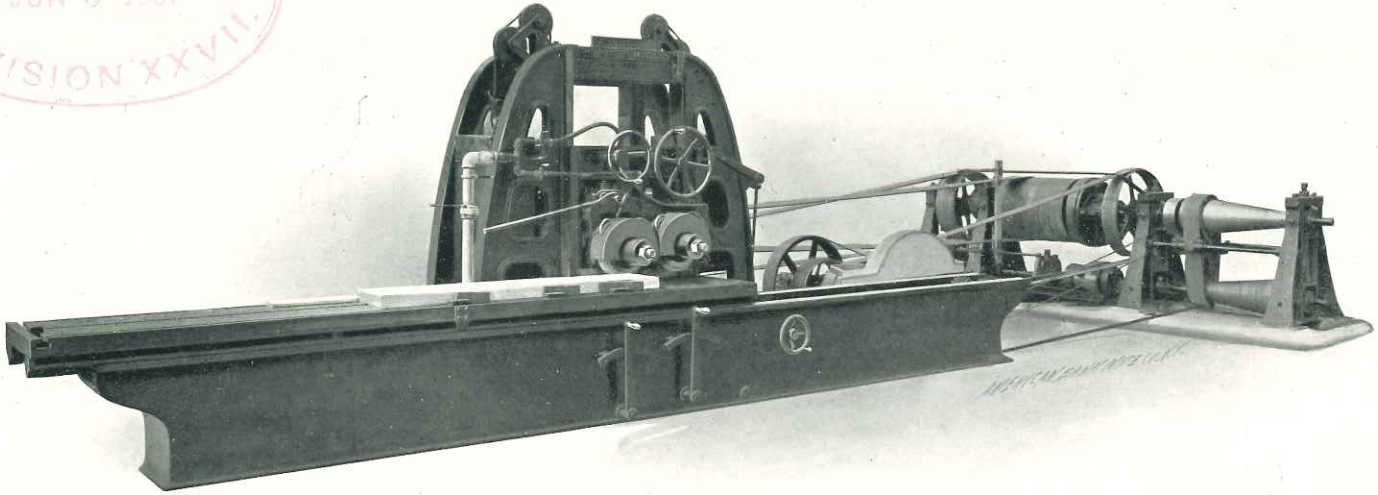
Maximum size of strip handled, 12 ft. x 2 ft., 4 inches thick.

Weight: 8 tons.

Horse power required: 10.

Floor space required: 15 ft. x 11 ft.

PATENT OFFICE
JUN 3 1907
DIVISION XXVII.



TWO-WHEELED MOULDER

TWO-WHEELED MOULDER

In many ways, the most unique of these machines is the Moulder. This is the direct result of experiments determining the cutting capacities of different grits of carborundum.

It consists essentially of two wheels, the spindles of which are held in a rigid frame. The marble is placed on a planer table and subjected to the abrading action of the wheels consecutively.

The wheels are first dressed to the contour of the mould to be cut. This is done by dressing tools and is an operation requiring but a short time.

The two wheels are of an entirely different kind, one being **very soft** and **very coarse,** and the other being comparatively hard and **fine.**

The marble in its passage meets the soft, coarse wheel first. This, known as the roughing-out wheel, is 1-16 of an inch above the other or finishing wheel. It has enormous cutting capacity, but does not leave a good finish. The marble now cut within 1-16 of an inch of its final shape, passes under the finishing wheel. This being fine gives the marble an excellent surface and reduces it to its exact contour. The finishing wheel being hard does not wear down, nor does the form of the mould to which it is dressed, become distorted. Furthermore, the roughing-out wheel, not only removes an immense amount of material but being soft, glazes very slowly. When this wheel does glaze, the operator can remove it very quickly without taking it off the spindle, and since it does not make the finishing cut, it is not necessary for it to retain the exact shape of the mould. The finishing wheel having very little work to perform glazes very slowly.

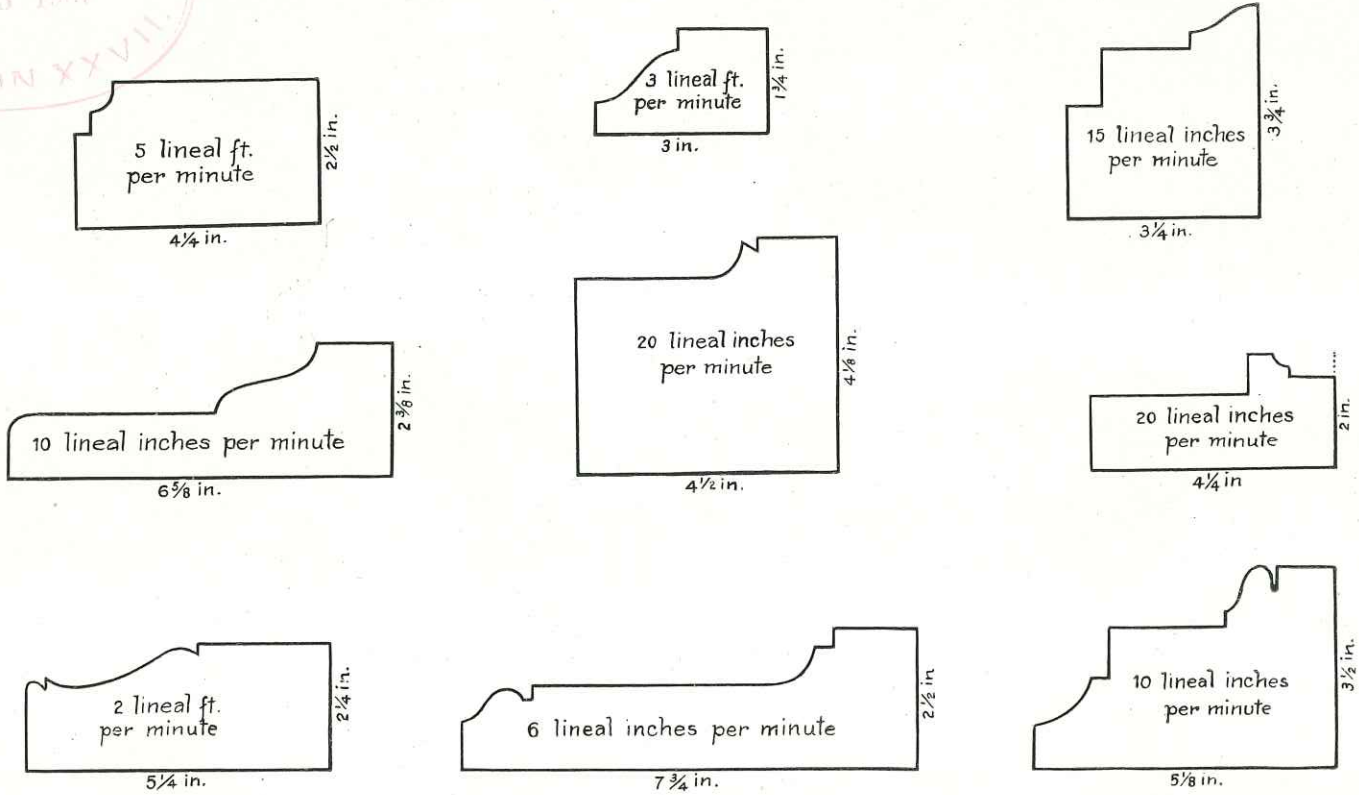
It will be seen from this the immense advantages of the two-wheeled, over the single-wheel process, which was the foreign method. Not only is an enormous amount of material removed at one cut, but this is done in the most efficient possible manner. One roughing-out wheel has the remarkable record of having removed 62 cubic inches in one minute.

Glazing, the great draw-back in the single-wheel process, is almost entirely eliminated. In some classes of work it is possible to run three days without dressing the wheels.

Diagrams of moulds and the rates at which they have been cut, are shown in the accompanying illustration.

The only field in which the single-wheel process has proved to be at all successful, is in small moulds; and even in these the two-wheeled process more than quadruples the work.

PATENT OFFICE
JUN 3 1907
DIVISION XXVII



Samples of moulds cut by the Two-Wheeled Moulder showing measurements of original moulds and the speeds at which they were cut

LATHE

The largest machine of the series is the Lathe. In general design it is the same as those in present use.

The machine has four heads, two on each side. The cutting heads, directly opposite each other, carry the carborundum wheels on horizontal spindles. The other two heads, also directly opposite each other, and carrying vertical spindles, are for fluting work.

Each head carries its own motor for operating the spindles. They are substantial ribbed casings, providing very solid supports for the bearings, and constructed so as to protect the motors from water and grit.

On one side of the lathe is a guide running the entire length of the machine. This can be adjusted to any curve. The heads being connected to the guide by a small pneumatic valve, follow the course of same and thus the column can be cut to any desired outline.

The lateral movement of the heads is controlled by a small pneumatic motor which in turn is operated by a valve opening and closing as it follows the guide.

The operator stands on a small platform attached to one of the heads and travels back and forth with it. Before him are valves and switches by which he controls all the movements of the machine.

When the fluting heads are to be used, the cutting heads are first moved to the end of the machine, and disengaged from the feed screw.

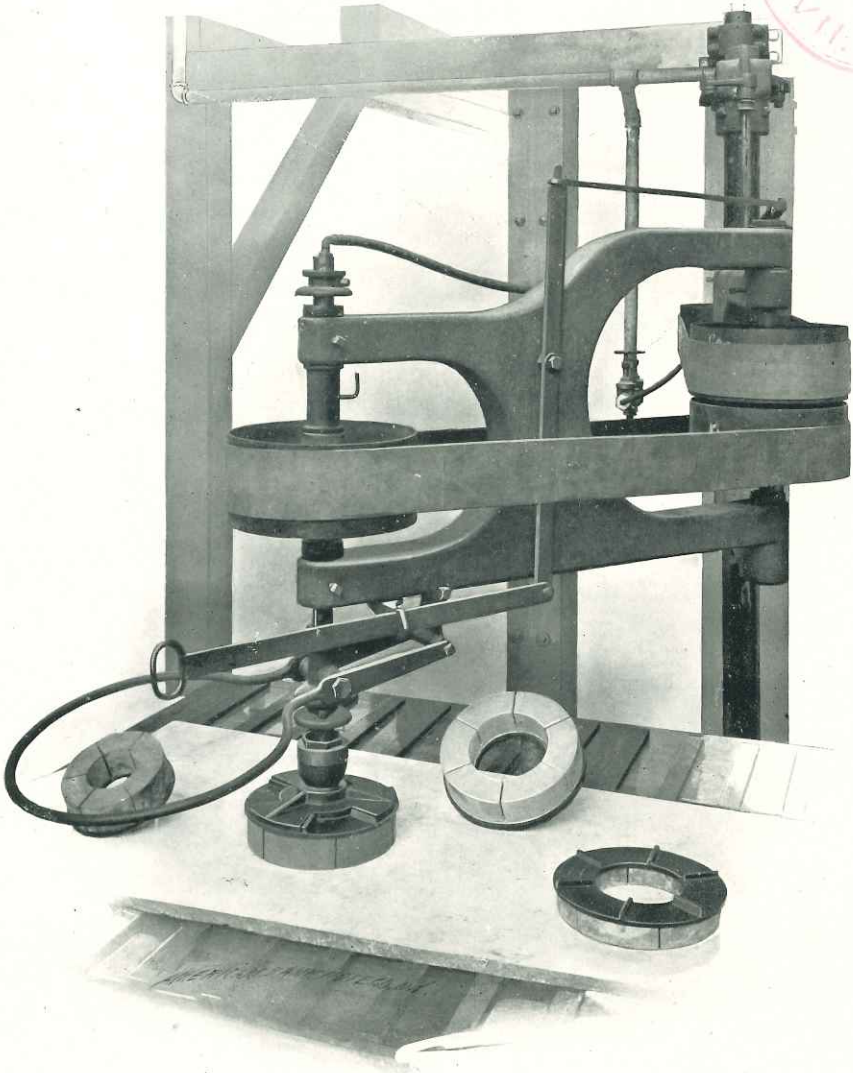
The pneumatic head-operating mechanism is extremely simple, uses very little air, and can be directly connected with the compressed air system of the shop.

The machine can be built with one cutting and one fluting head both being operated on the same side. Though this does away with the mechanism on one side of the column, fifty per cent. of the efficiency is lost.

The largest column this lathe will take is 20 ft. long by $3\frac{1}{2}$ ft. in diameter.

Weight: 40 tons.
Cutting head motors: 25 horsepower each.
Fluting head motors: 20 horsepower each.
Operating motor: 20 horsepower.

PATENT OFFICE
JUN 3 1907
DIVISION XXVII.



POLISHING RINGS

POLISHING RINGS

More ingenuity has been expended in devising an efficient polishing ring than on any other piece of mechanism used in the marble trade.

The industry has long been in want of a standard, simple device of this kind and the Company believes it has successfully met this want. The device offered by us is not only of the simplest possible construction, but is very easily handled.

It is of scientific design, built in accordance with the theory described in the appendix and realizes to the utmost the principle upon which all polishing rings should be constructed; that is to say, it has a maximum number of abrading particles, with a minimum variation of speed.

Rings having unusual shaped segments should be discarded. They show no increase of efficiency and are more costly. Most of them are placed too close to the centre, are held by various awkward contrivances and are so small that their lives are short.

We believe that our ring avoids all these errors and is the most successful on the market.

It is possible to make a single ring that will do the work of the coarse grit, fine grit and hone, taking the slabs directly from the saws and preparing them in one step for the mop. This is, however, a very wasteful process, because it necessitates the use of a grain which is too fine to properly coarse grit or too coarse to properly hone. For it is a physical principle that the rings should become finer in grit as the finishing progresses.

We would also call attention to the ease with which the rings can be changed, occasioning no loss of time.

Its greatest success, however, is due to the correct choice of abrasives and bonds.

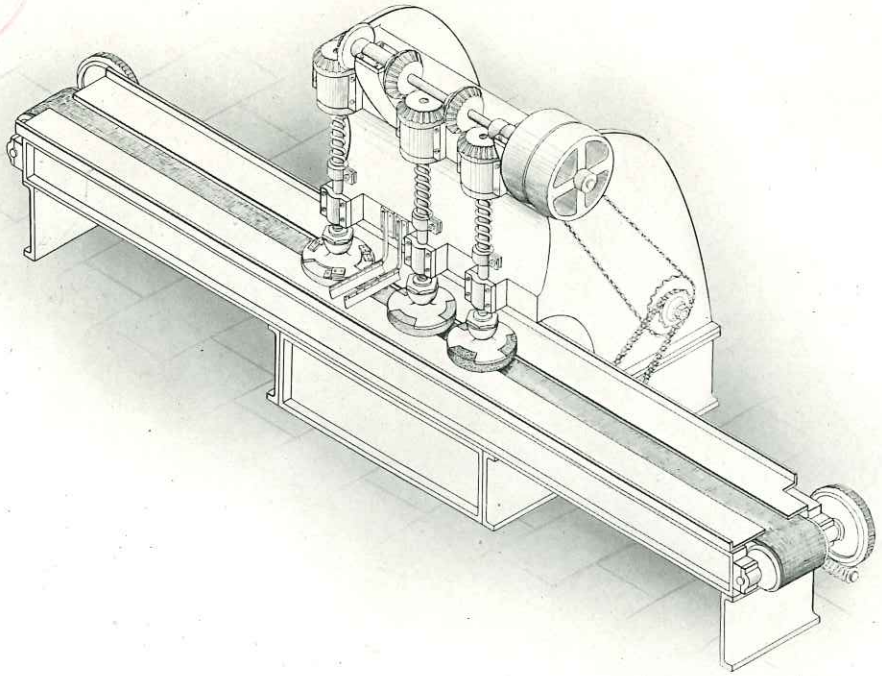
It has been impossible to use carborundum owing to its sharpness. In its place we use other suitable abrasives.

The rings consist of six segments which are cemented into slight indentations on a thin iron plate. On the upper surface of this plate, are lugs, between which fit the three arms of a web; this latter being fitted by means of a universal joint, to the operating shaft. Water is run through the shaft passing through the joint and web, falling to the center of the ring. From here it finds its way out through the interstices between the segments. It serves both to carry the abraded marble away, and to keep the bottom of the ring clean.*

It may be seen that by raising the shaft of the polishing machine, the ring is at once disengaged, and it is only a matter of a second, to replace it with another or with the polishing mop.

*The segments are 3 inches thick; are easily fastened to the plate, and can be used down to ⅛ of an inch in thickness.

PATENT OFFICE
JUN 3 1907
DIVISION XXVII.



BASE FEED POLISHING MACHINE

These rings never leave the flint veins exposed, handle any kind of marble, rub edge and corners without injuring them, and can be successfully used on base as narrow as four inches.

It is possible for one machine to fine grit, hone and polish 50 sq. ft. per hour.

There are two sizes of rings:

Large size: 14 inches in diameter.

Small size: 8 inches in diameter.

Outfit includes: One spindle, one universal joint, two webs, (large and small), and six plates, (3 large, 3 small).

These outfits which are held by patents are sold on condition that the polishing rings be purchased from this Company only.

BASE FEED POLISHING MACHINE

This machine requires but little description. It is an adaptation of the polishing rings (heretofore shown), to base work, whereby strips can be easily polished entirely by mechanical means.

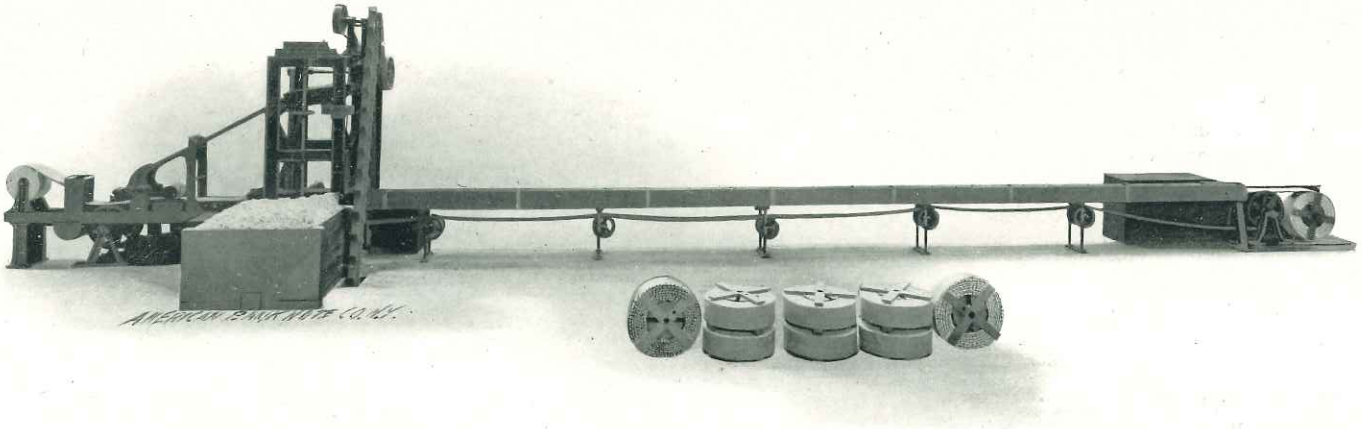
The base is fed to the polishing rings by an endless belt moving very slowly. There are two rings, a fine grit, and a hone followed by a mop, all operating at once.

The guides for holding the marble base in place can be adjusted to accommodate any width of strip up to 14 inches.

Horsepower required: 10.

Weight: 5 tons.

PATENT OFFICE
JUN 3 1907
DIVISION XXVII.



MOSAIC MACHINE—Showing Spools ready for shipment

MOSAIC MACHINE

This machine performs a class of work which has never successfully been done by mechanical means.

Floors laid by it are superior to those laid by hand. Not only are the lines absolutely straight, owing to the long lengths in which the mosaic is laid, (a feature permitting hallways being laid lengthwise), but it is more easily packed.

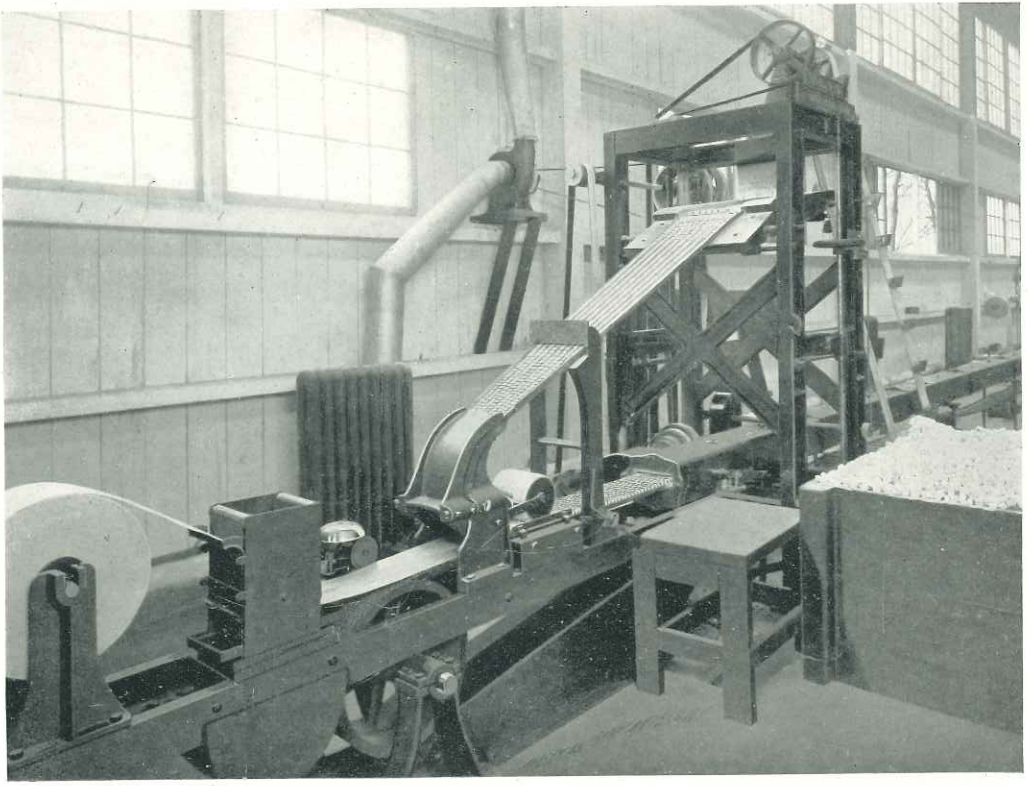
The plaquettes are first thrown into a hopper beside the machine, from which a trip allows a definite number per minute to fall upon a sieve to the sub-hopper. A belt conveyer takes them from here to a vibrating tray seen in the upper part of the center of the machine. The plaquettes are shaken so that they fall upon their flat sides, and sliding along the inclined surface, find their way into small tubes. The plaquettes run down, floor side up, past the operator (who removes the defective pieces) and turning upside down, are laid upon a strip of glued paper. The paper seen in the roll on the left first passes through a glue box. Here it is uniformly coated with the requisite amount of glue. It next passes under the brass "turn-over" and receives the stream of inverted plaquettes.

The latter are now packed together, and the lines straightened by two brass strips. At the same time, they are pressed upon the paper by a felt roll. The paper now laden with mosaic is carried along by an endless wire mesh belt, into the dryer. This consists of an iron box 35 ft. long, in the bottom of which are steam pipes. In addition, a constant draft of hot air is forced through the box by means of a blower.

The plaquettes, upon emerging from the dryer, are securely fastened to the paper, and the ribbon of paper and mosaic is wound upon a spool containing 22 sq. ft. The strips on these spools are 6½ inches wide and 40 ft. long.

The machine will handle any sized plaquettes, it being only necessary to change the tubes, three sets of which, laying five-eighths, three-fourths, and seven-eighths plaquettes respectfully, are supplied with every machine.

PATENT OFFICE
JUN 2 1902
CLASS XXVII
DIVISION



MOSAIC MACHINE--Detail

The machine will also lay colored line borders.

As said before, the operator removes all the defective pieces. Consequently the same care is used selecting the plaquettes as is exercised in hand work.

The machine can be adapted to use ceramic.

Weight: 3 tons.

Capacity: Depends upon operator and mosaic. With well cut mosaic, the machine will lay 70 sq. ft. per hour.

Floor space required: 48 ft. x 7 ft.

Maximum height: 9 ft. 6 in.

Horsepower required: 3.

It is operated by two boys.

PATENT OFFICE
JUN 3 1907
DIVISION XXVII.

LAYING MOSAIC FLOORS FROM SPOOLS

LAYING MOSAIC FLOORS FROM SPOOLS

The accompanying illustration shows the method of laying mosaic as it comes from the mosaic machine.

First, the mastic is spread on the floor. Two men then carry the spool on a rod, at the same time unrolling the paper containing the mosaic. Consequently, the mosaic is laid as fast as a man can walk.

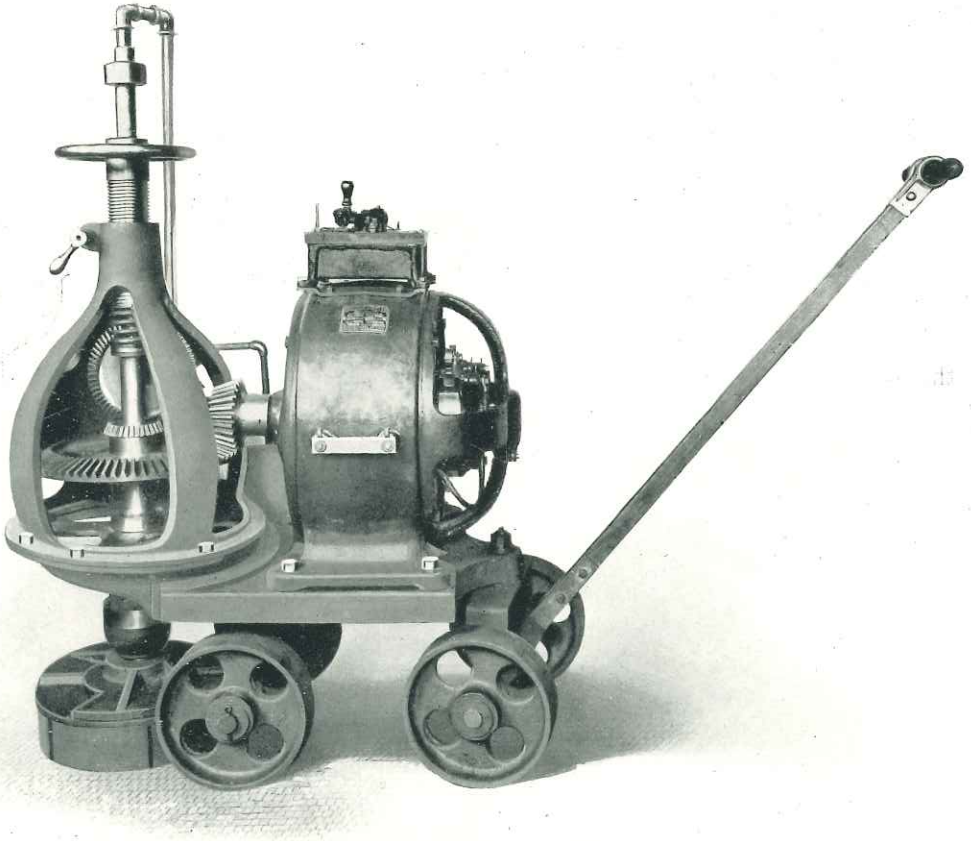
The paper is then moistened. By means of a straight edge and a hammer the lines are made true and the mosaic is packed against the floor already laid so that the lines between strips are obliterated. After being lightly pounded, the floor is rolled, paper removed, and the interstices between the plaquettes grouted. As soon as the cement has hardened, the floor is ready for polishing.

Over 50,000 sq. ft. of mosaic have been laid by this machine in some of the large buildings of New York and the work has been declared by competent experts to be equal and in some ways superior to the best hand-laid floors.

By this method over 200 sq. ft. per mechanic can be laid in a day of 8 hours.

The lines in floors laid by this method are faultless.

PATENT OFFICE
JUN 3 1902
DIVISION XXVII



FLOOR POLISHING MACHINE

FLOOR POLISHING MACHINE

The accompanying photograph illustrates our floor surfacing machine.

After a careful investigation of the various types now on the market, a machine having a single wheel has proved to be the most efficient.

This machine is fitted with our polishing ring attachment, heretofore described. The kind of abrasive bond, etc., is carefully selected for the work to be done.

A small circulating pump, automatically supplies the requisite amount of water.

The finish left by this machine is excellent and floors rubbed by it require much less subsequent treatment than floors rubbed by machines now on the market.

On very uneven mosaic or terrazzo floors, a coarse ring is first used to grind to a level surface, after which a finer wheel is substituted for finishing.

The machine is simple, of strong construction, and all wearing parts are carefully protected.

Weight: 800 lbs.

Horsepower: 5.

Capacity: Terrazzo floors, 25 sq. ft. per hour.
Mosaic floors, 50 sq. ft, per hour.

Motor: 200 volts, direct current.

This machine is sold upon condition that the rings are purchased from us only.

APPENDIX

In addition to the machines shown in this catalogue, this Company is engaged in designing, and experimenting with other important machines and devices for use in the stone trades.

It is also prepared to design and build machines for any special class of work.

ABRASIVES

Article by J. Royden Peirce, republished from the Engineering News.

KINDS OF ABRASIVES

SAND STONES. The oldest type of abrasive wheels are those composed of sand stone. Though still used in a few limited classes of work as cutlery, tool finishing, etc., they are almost entirely superceded by the later abrasives. Their superiority lies in their slow grinding and the consequent retention of the temper of high grade steels. Emery wheels will accomplish the same result if a proper selection is made, but considerations of cost, prejudice and ignorance keep a demand for the primative grinder.

EMERY. Emery or Aluminum oxide, with a mixture of oxide of iron, generally about 40 per cent., is by far the best known. It is a black compact material, has the glassy lustre peculiar to abrasive substances, and breaks with a conchoidal fracture.

ALUNDUM (Artificial Corundum). This abrasive is a product of the electric furnace. It is a fused aluminum oxide, with a purity of about 95 per cent. Its fracture is conchoidal, though it seems to tend more toward a crystalline structure than emery.

ADAMITE (Austrian Artificial Emery). This abrasive also is a product of the electric furnace. If color is an indication of purity, it is inferior to alundum, though it is claimed that the grains are tougher.

CORUNDUM. Corundum is a pure oxide of aluminum and is found in nature. It generally has a

crystalline fracture. It is probably harder than alundum though more brittle.

CARBORUNDUM. The most remarkable artificial abrasive known is carborundum. It is a silicide of carbon, with a pure crystalline fracture of remarkable sharpness. When the crystals break they invariably leave a new sharp edge.

BORIDE OF CARBON. The twin sister of carborundum and a substance which Moissan claims is much harder. Unfortunately it is disintegrated by air and its practical use is, therefore, impossible. Possibly future experimentors will overcome this disadvantage, but the high price of borax will prevent its competing with carborundum.

BORIDE OF SILICON. This material is similar to boride of carbon and has the same properties.

TITANIUM CARBIDE. Outside of aluminum oxides and carborundum this abrasive seems to be the only one which has any practical future before it. At a high heat, however, it unites with the nitrogen of the air, consequently it cannot be used in kilns. In the non-vitrified bonds, however, and for certain grades of finishing and polishing cuts it would appear to have commercial possibilities. It is a bright, silvery material of no discernible fracture.

The four elements, carbon, boron, silicon and titanium, have the quality of forming very hard compounds when used in the electric furnace. The author has tried many combinations of them but aside from carborundum, none except titanium carbide, appears practical.

BONDS

Bonds are rather a matter of chemistry than physics, but we cannot pass the subject without pointing out a few facts in relation to them. There are three properties which the manufacturer has to take into consideration—their hardness, toughness and elasticity.

The elastic bonds, like rubber and shellac, allow a much greater latitude in the selection of grades and grits, that is to say, in the vitrified bonds one must be very careful not to get a wheel too hard or soft, or too course or fine, whereas in the elastic bonds it is not necessary to be so cautious.

PRELIMINARY CONSIDERATIONS

Among the many recent developments in shop practice none is of more importance than the growing use of abrasive wheels. Though emery wheels have been known for many years, their use for accurate work and handling the harder varieties of steel is of recent origin. As yet, however, no attempt has been made to scientifically investigate the laws which govern their use; and, although every maker gives tables of the

correct wheel for different purposes, he does not inform the purchaser that his rival's product is superior to his own for some uses.

It is commonly believed that the harder the abrasive the better adapted it is for hard materials, and that the coarser the grains of which it is composed the greater its cutting effect. As a matter of fact, this is true only within limitations, and these limitations are so many and important that the above rules are very unsafe guides. For instance, carborundum, while very effective in cast iron, brass and particularly in marble, does not show so great an efficiency in steel. On the other hand, the emeries and corundum, natural and artificial, though inferior to carborundum in hardness, often equal and, in some cases, surpass it in cutting effect in very hard materials. This parodoxical fact, which is well known to the trade, needs to be explained, and we attempt to do so in this article.

The second assertion that the coarser the grain the greater the cutting efficiency is another fallacy. This is true only up to a certain degree of coarseness, different for each combination of abrasive and material, and beyond which the efficiency again falls.

Below are a few illustrations:

Carborundum	Glass	60 grit
Emery	Hard Steel	24 grit
Emery	Cast Iron	16 grit
Carborundum	Cast Iron	16 grit
Carborundum	Marble	4 grit

Here, again, we encounter a peculiarity which has been too little investigated.

Before going further we must call attention to the two different classes of work which wheels are required to perform, namely: finishing and cutting. In the former case the abrasive is called upon only to leave a satisfactory surface. Its duty is light, its life long, and its structure and operation quite different from the second case, the efficient removal of material. For this latter duty the wheel is coarser, generally of softer bonding material, and often requires a different abrasive.

These two requirements are entirely different and should not be confused. Laws or rules which answer for one are inapplicable to the other.

The following considerations apply almost entirely to the *cutting* efficiency of wheels, and where anything else is meant we will specifically call attention to it.

Having given a few illustrations of the utter inadequacy of prevailing rules to satisfactorily account for abrasive phenomena or for use as shop guides, we will look at the actual conditions which the abrasive particle encounters in its passage over the material it is cutting, and see if we can discover a satisfactory cause for the behavior of different combinations.

PRINCIPLES OF ABRASIVE WHEELS

There is no reason to suppose that a microscopic abraiding particle acts in a manner different from that of an integral cutting tool; and the following proposes to analyze the action of abrasive wheels by assuming the cutting efficiency to be dependent upon the simple physical principles of a steel tool.

The amount of material removed by the latter is dependent upon the depth of cut, width of tool-face and speed of passage of tool over work. That is to say, the efficiency of abrasive wheels, other things being equal, is proportional to

(1) Speed.
(2) Total face of cutting particles engaged.
(3) The penetration of particles in material.

(1) *Speed.* Claims have been made that an increase of speed above 5000 feet per minute produces no proportional increase of material removed. We can only partially agree with this as there is no mathematical reason why such should be the case. There are, however, many limiting conditions, the most important being the strength of the bond, and, consequently, the wheel. In experimenting it must also be borne in mind that in comparing different speeds the tangential pull must be the same, and, also, that as the material is worn away faster at high speeds, there is probably a greater clogging of the abraded substance between the wheel and material. This either decreases the penetration and so detracts from the expected advantage of increased speed, or requires a greater pressure to keep the particles engaged an equal amount. In either case the result is the same, the material removed being not directly proportional to the speed.

(2) There will probably be less doubt felt as to the truth of our second rule,—the efficiency is dependent upon the total aggregate of the cutting faces engaged. It is a matter of elementary knowledge that, other things being equal, the wider the face the more the wheel removes. There is no reason why this should not be true also of the minute particles themselves.

The cutting face of the wheel, being made up of many particles, it is advantageous to have as large an aggregate of cutting edges in engagement as possible. Presuming their cut to be infinitesimal, a straight line parallel to the axis of the wheel is ideal; but since this is not the case a serrated surface is preferable. In this way a larger surface is actually cutting. The greater

ease of removing the abraded material by its retention in the pores of the particles must not be lost sight of. From the diagram below the advantage of a serrated edge is clearly seen.

(3) We come to the last and most intricate condition—the penetration. The distance which a particle forces its way into the material is dependent upon the perpendicular pressure to which it is subject. This, while a simple condition in a straight line, becomes complicated when there are a large number of particles, and when they are distributed upon the surface of a wheel.

In scientific order the cutting surface should follow the penetration, since the edge engaged is jointly dependent upon the nature of the surface and the amount it is forced into the material.

We may premise a common sense rule that there should be as much pressure as possible, limited by the strength of the wheel and the rapidity with which the particles dull.

EMERY WHEELS. Manufacturers make the bond which holds the abrasive particles together, of a hardness which is just sufficient to allow them to be pulled off by the material when they are dull. This automatic sharpening is the most unique, and probably the most important feature of abrasive wheels. Upon it depends the length of time a wheel will continue efficient cutting. A wheel that is too soft, though a good cutter, owing to the continuous presence of fresh, sharp particles, is a wasteful instrument since it soon wears away. On the other hand, a wheel that is too hard requires too frequent dressing, for the dull particles remain in the sockets and abrasion soon decreases.

In consequence of the necessity of allowing the particles to be removed, the strength of the bonding material is limited; this, in turn, limits the strength of the wheel and the amount of pressure that can be applied. In practice, however, glazing limits the pressure long before the strength of the wheel.

Let us see for a moment how minute a cut each particle makes. A twelve-inch 16 mesh wheel, with a 1-inch face, going at 2000 R.P.M., and removing one cubic inch of iron per minute (an extreme case) and having $\frac{12}{2}\frac{16}{} = 300$ particles around its circumference, gives every particle $\frac{1}{300} \times \frac{1}{2000} = \frac{1}{600,000}$ of an inch to remove each time it passes the iron bar. This, of course, is only strictly true of a straight line across the face of the wheel, but presuming the actual cut of each particle to be five or ten times as great, it is still very minute. Suppose only one-fourth of each particle protrudes from the bonding material; that is, $\frac{1}{64}$ of an inch, and suppose also the individual cut is ten times $\frac{1}{600,000}$ or $\frac{1}{60,000}$ of an inch. It will be seen that only $\frac{1}{1,000}$ of the protruding part is embedded in the material. We have given a limiting example as an

illustration for the pressure could not be greatly increased.

Referring to the above diagram, it will be seen that in the first case increasing or diminishing the depth of cut increases or diminishes the amount of material removed by the same amount.

In the second case, however, we encounter a different condition. In extremely light, or skin cuts as they are known, the crystalline abrasive is not efficient, as only the points are engaged. Should the two diagrams be fair representatives of the two surfaces, and although a microscopic examination shows a very promiscuous arrangement, still their general surface is much like the diagram, given the same penetration from tip to bottom of the particle engaged, the dull abrasive will always lead in material removed.

It is, however, evident that more pressure will be required to force the dull abrasive in the work than the crystalline. On the other hand, a pressure on the tips of the crystals is apt to break them, especially so in carborundum, which is the more brittle. In a material which will not break the crystals, however, their sharp contours enable them to make something more than the microscopic cuts of their duller rivals. This explains the remarkable fact that though carborundum, which is the hardest abrasive known, (except the diamond) while it shows marked superiority on cast iron and brass, cannot show the same relative efficiency on hardened steel. Whereas, in more yielding substances like cast iron, brass, marble and leather, the ease with which the crystals force their way into the work and the great length of time they remain before breaking or dulling, puts carborundum in the lead. That is to say, the efficiency of carborundum is mainly due to its penetration.

It is in extremely soft materials like marble that the great importance of the efficiency of penetration is seen at its best. Indeed, it is to its quality of sharpness, much more than to its hardness, that it has captured the soft stone field by such large odds. As a corollary from this it follows that where carborundum is substituted for emery or sand in soft materials, less pressure should be exerted on the wheel.

Having examined the importance of the role, which penetration plays in the efficiency of abrasive wheels, we are in a position to notice limitations of coarseness.

The coarser the wheel, the fewer cutting particles engaged, and, consequently, each article must do more work. In the case of emeries and corundum, whose cuts are very light, and which require great pressure to secure penetration, we are limited by the pressure which we can apply, both by the strength of the wheel and by the rapidity of dulling.

In carborundum, we are limited by the brittleness of the crystals, since a hard material tends to break

them. In both cases, therefore, there is a limit to the degrees of coarseness.

We have indicated a few of these in the table in a former section of the article. These limits, though very definite things are but little understood and still less appreciated, yet it is impossible to use abrasive wheels intelligently without taking them into consideration. Indeed, the fact that course carborundum (as coarse as 2 grit, that is, each grain is ½ of an inch in its largest dimension) is a remarkably successful cutter in marble has only recently been discovered, although the substance has been known for ten years, illustrates how imperfectly the limiting properties of the size of grain have been investigated.

At this point it may be well to consider the probable possibilities of diamond wheels should the jewel ever be made commercially.

It can be predicted with fair certainty that for finishing cuts, though the wheels will glaze very much less, it will not leave a better surface nor remove the material with any greater rapidity than emery. Indeed, it is a physical principle that a certain finish limits the size of the grain and therefore, the form of particle remaining the same, the amount of material removed. In very soft materials like marble, slate, or the lime stones, carborundum has no cause to fear the introduction of the diamond, for its great penetrative power will always keep it in the lead.

In the medium substances, however, brass, cast iron, etc., the great wearing qualities of the diamond will make it unrivalled, and while in the hard materials as hardened and maganese steel, though it will not be more efficient for finishing cuts, for roughing out cuts, it will immediately displace the aluminum oxides.

FORM OF WHEEL

DISKS. The cutting efficiency of a disk is proportional to its area multiplied by the speed of a circle with a radius $\frac{2}{3}$ r. They are not very much used, owing to the outer surface wearing away faster than the centre and leaving it finally spinning about a small central area much like a top. A hollow ring, however, avoids this evil, and if it is broken by occasional openings to allow the abraded material to escape, it is excellent for certain classes of work.

As the cutting area is much greater than the shear cut of a wheel, the pressure per unit is much less, consequently the bond should be very soft. Furthermore, a dull abrasive should always be used, for since the pressure per square unit is light, the penetration is still

small and there must be as large a total of cutting faces as possible. For instance, in marble, carborundum, which is unrivalled for shear cuts does not give as good duty in disks or hollow rings as emery.

This again is an illustration of the important roles penetration and cutting surface play, and emphasizes the fact that the form of the grain is of much more importance than its hardness.

FINISHING CUTS

Carborundum can rarely be used for polishing. The sharp points of its crystals have a tendency to scratch which can only be overcome on materials that are extremely hard.

When selecting the abrasive it must he borne in mind that an elastic bond will allow a coarser grain to be used, as will a harder material. That is, if a shellac wheel is used instead of a vitrified wheel and they are of the same grit, the finish of the shellac wheel will be smoother, and, if the same wheel is used on cast iron and steel, it will leave a finer finish on the latter. Furthermore, if an emery wheel gives a desired finish, an alundum wheel to give the same finish must be a grade or two higher, and a corundum wheel still finer.

While many, possibly the majority of wheels, are selected as a compromise between finish and speed of removal of material, it must be understood that wheels which perform the two classes of work are quite different.

DEPTHS OF CUT, Etc. In designing abrasive machinery it is frequently necessary to know the pressure, etc., exerted upon the wheel or material when something more than skin cuts are taken, and below are given a few of the more important relations.

The first diagram gives the vertical and horizontal forces which the wheel exerts when the subtended angle and tangential force are given. It assumes that the

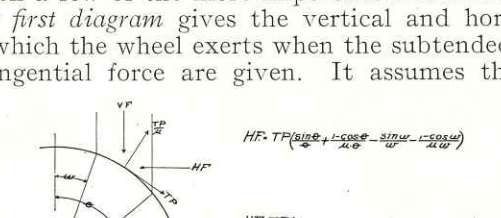
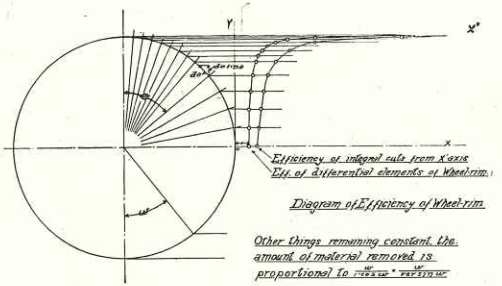


Diagram giving values of Vertical and Horizontal forces in terms of subtended angle and Tangential pull

abrasion is equal in equal sections of the arc. This is not strictly true, however, though for general purposes the formula is sufficiently accurate.

The second diagram illustrates the cutting efficiency of the wheel rim. The material is presented to the wheel along the axis of X. It will be evident that at


Y
X
Efficiency of integral cuts from X axis
Eff. of differential elements of Wheel-rim
Diagram of Efficiency of Wheel-rim
Other things remaining constant, the amount of material removed is proportional to

the top of the wheel there is much more abraiding surface removing a given section of material than along the axis running through its centre.

On a differential arc $d\theta$, the relation of cutting surface to material cut is represented by $\frac{d\theta}{d\theta \sin\theta}$ or $\frac{1}{\sin\theta}$ This is the cosecant. The X ordinates of the cosecant curve, therefore, show the efficiency of the rim at that point. The efficiency of integral cuts are proportional to the average ordinate of their cosecant curves, or what is easier to determine $\frac{\theta}{\text{versin}\theta}$. It will be seen how very efficient light cuts are in comparison with those which extend over a greater portion of the rim. This fact, well known in wood saws, is equally important in abrasive wheels.

Below is given a table showing the limiting size of various combinations and also the increase of fineness required by the more crystalline abrasives to produce the same finish.

CLASS OF WORK	Emery	Alundum	Corundum	Carborundum
Glass and Marble Polishing	150	200	240	....
Fine Hardened Steel Work	40–80	46–100	50–120	60–150
Sharpening Milling Cutters.....	40–50	46–50	46–60	50–80
Gener'l Machine Shop Use.....	20–24	20–30	20–36	24–40
Brass Castings.....	16–20	20–30	24–36	30–40
Agricultural Implements.....	14–20	16–24	16–30	16–36
Rough Castings.....	10–16	12–16	12–20	14–36
Marble	....	....	....	2–4

AMERICAN BANK NOTE CO., NEW YORK.